OF THE CALIFORNIA DENTAL ASSOCIATION

Journal

MAY 2008

Optimal Dentofacial Esthetics

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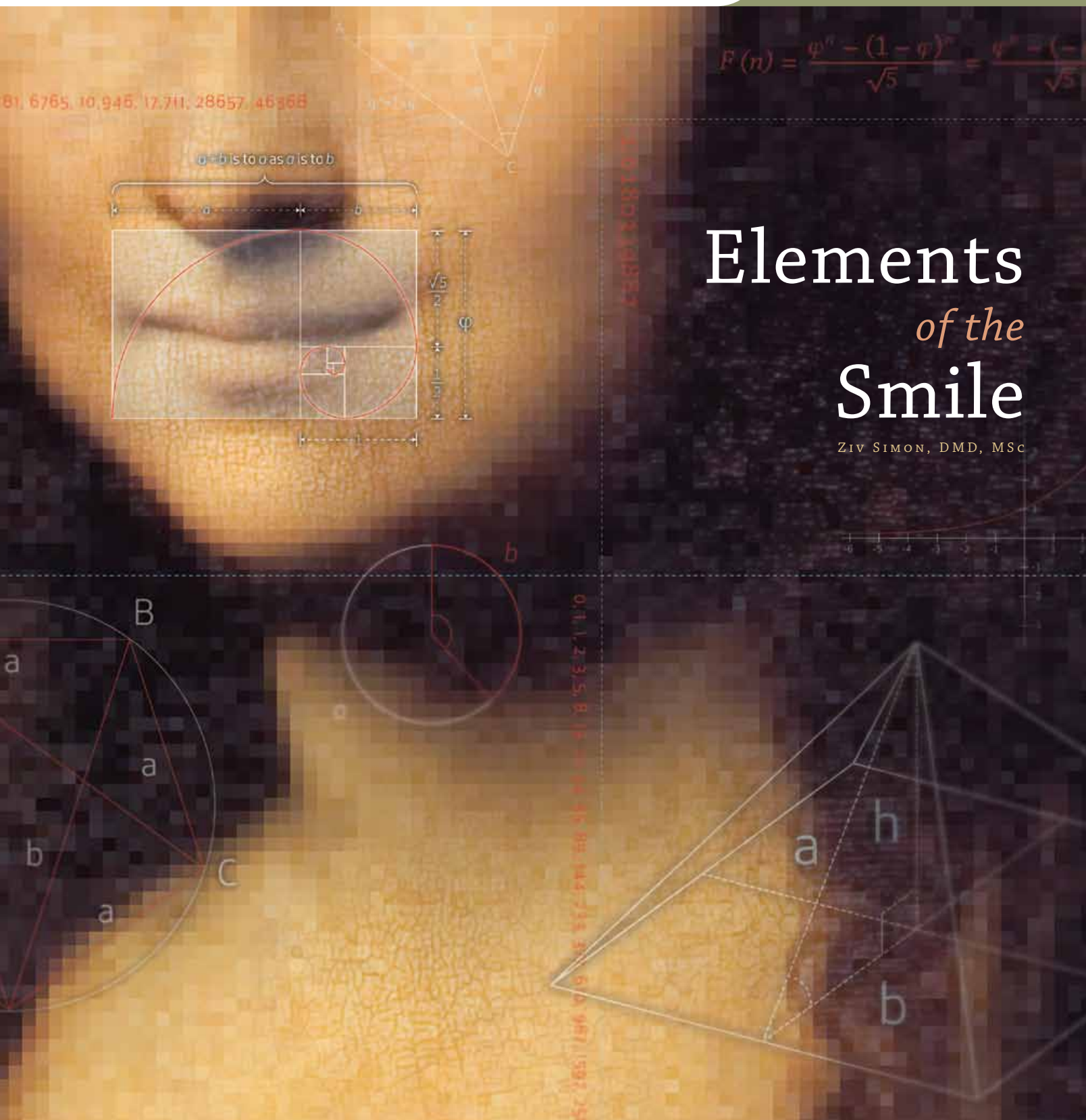
Smile Design



Elements *of the* Smile

Ziv Simon, DMD, MSc

OF THE CALIFORNIA DENTAL ASSOCIATION
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DEPARTMENTS

FEATURES

CDA JOURNAL, VOL 36, Nº5

Parental Responsibility: The Other Side of Access

STEVEN A. GOLD, DDS

Addressing our nation's unmet dental needs has taken center stage in our profession. The catchphrase "access to dental care" has made its way into the vernacular of 21st century America from policy-makers in Washington, D.C., to those in Sacramento to mainstream news and this has been driven by several spectacular and public incidents. The most notable was the death of a Maryland youth, Deamonte Driver, who succumbed to a cellulitis, the origin of which was a dental abscess.

The fact that a child could be lost to a disease process that was completely preventable was both shocking and unacceptable. The public began to learn about the current state of childhood caries and its potential consequences. They also were given a glimpse into the shortcomings of public dental service programs, something we in the profession have been struggling with for years. Chronically plagued by public underfunding, the very programs designed to help the needy too often fail them. Thus, this segment of our population has been the target of efforts by both policy-makers and the dental profession to provide them with the dental care they need.

We have seen across the board that when it comes to addressing these issues, dentists are both giving and caring. Participation in programs like Give Kids a Smile, volunteerism at community clinics, financial support of charitable organizations like the CDA Foundation and the quiet, private donation of dental services by individual dentists in their practices bear this out. Still, many of us

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live and practice in communities where the reaches of poverty are minimal. In California, only 40 percent of dentists participate in Denti-Cal and even fewer in Healthy Families, two of the programs designed to help the needy.

The rest of us might naturally expect to see a proportionately smaller incidence of childhood caries in our practices. Statistically this may be true. Statistically, Deamonte Driver should not have died. The fate of one child can make statistics meaningless. So when two children presented as new patients in my practice recently with rampant caries, both from nonminority families living well above the poverty line, I was struck by the fact that dental disease does not discriminate.

As a profession, we seem comfortable focusing our efforts on economically disadvantaged children. By definition, the solution to their dental disease problems is simple: to give. When children of means suffer from identical dental disease, the solution is not as easy. We can begin the search for one by remembering the pathogenesis of dental caries. There must be two things present to form tooth decay: pathogenic bacteria colonizing the tooth surface in the form of dental plaque and fermentable carbohydrates, usually in the form of sugar. We might also contend that an absence of certain prevention modalities can increase one's susceptibility to caries, namely dental sealants and fluoride used both systemically and topically. So in this generation of "kids who have everything," where in this disease process are they failing? Or more appropriately, who is failing them?

We can certainly point a finger at some broader entities; for example, a food and beverage industry that pedals obscenely sugar-laden products to our children. Or perhaps even our own dental profession, which fails to adequately stress the importance of early dental visits so dentists and hygienists can teach children proper brushing and flossing techniques and good nutritional habits. But the identity of those individuals who assume exclusive responsibility for a child's well-being was revealed to me four years ago when I became one: the parents.

There is nothing like having a child to make one aware of the responsibility of being a parent. It is sometimes too easy to be critical of parenting styles that, perhaps, differ from our own. So rather than criticism, I present the following observations. Children arrive at pre-

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school at 7:30 am eating their morning snack: for one child, a bag of Fruit Loops cereal with marshmallows and a box of apple juice; for another, candy. When asking parents if they brush their child's teeth, more than one has responded, "Well, I try but she doesn't like it so a lot of times I don't."

Parents refuse to schedule recommended dental appointments for their child citing conflicts with other activities ranging from sports practice to dance class, to school play rehearsals. Parents arrive with their child to a dental appointment in a $60,000 SUV, yet refuse to pay for recommended dental sealants because it is not covered on their dental insurance plan.

It would appear that observations such as these are merely one manifestation of skewed priorities on the part of today's parents. Young children cannot be expected to make important decisions such as healthy diet choices on their own, nor can we expect them to execute proper preventive oral hygiene practices. As a result, their well-being is being compromised by parents who fail to take proper responsibility for such well-being.

Preventable childhood diseases such as dental caries and obesity are prevalent today due to complex societal issues. But not one of these issues can overcome a strong dose of parental responsibility. For this, there is little the dental profession can do, except, perhaps to set the positive examples we would want to see in others, and hope that another child does not become the next Deamonte Driver because her parents failed to take responsibility. ■■■■

Address comments, letters, and questions to the editor at alan.felsenfeld@cda.org.

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'Safety' of Formocresol Contested

I am responding to recent articles on the "safety" of formocresol in dentistry. Having started the debate in 1981, I have had the benefit of reviewing the literature as it has developed, without bias and with consistent regard for scientific principles and protocols. My concern is for your readership, well-meaning clinicians who might be confused by position papers that distort the overwhelming body of evidence that cite the genotoxicity, mutagenicity, carcinogenicity, and toxicity of formaldehyde.

It is ludicrous to suggest that because other medicaments and prescribed medications in dentistry might also have deleterious effects it is therefore "safe" to use formocresol. It is a "tad" unscientific to further tell dentists that it is OK to add formaldehyde to their patients' systems since its ingestion/inhalation is a part of life. Repeating the nearly 100-year-old archaic notion of how to deliver a safe dose by squeezing a soaked cotton pellet is surprising in today's sophisticated techno-based world. Hand-picking studies that have aberrant or inconclusive results when weighed against the accepted evidence become self-serving while simultaneously destructive to clinicians seeking the best for their patients.

Much of the research about formaldehyde was firmly established as far back as 30 years ago. Alternative medicaments have been proposed for many years with mixed results. Equal or better clinical outcomes have been demonstrated with some non-aldehyde compounds; ferric sulfate, white mineral trioxide aggregate, white Portland cement and beta-tricalcium phosphate.

Systemic distribution after formocresol polpotomy is irrefutable. Formocresol interferes with healing. As recently as March 2008, research has shown that formocresol causes genetic damage.

I urge dentists to rethink their use of formocresol. In 1981 (*Journal of the American Dental Association*) and again in 1998 (*Journal of Clinical Pediatric Dentistry*) I concluded, "If a medicament like formaldehyde is clearly not a necessary adjunct, then it may be wondered why it is used at all."

Children should not be exposed to formocresol since there isn't any conclusive evidence warranting its use.

BRADLEY B. LEWIS, DDS

Dr. Lewis is the former postdoctoral endodontic coordinator at St. Luke's-Roosevelt Hospital Center, New York, attending at Columbia University, School of Dental and Oral Surgery, and associate at Cedars-Sinai Medical Center, Los Angeles.

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Deborah Zenke

Dental Sealants: Key Points From the 2008 ADA Report

The American Dental Association has published evidence-based clinical recommendations for the use of pit-and-fissure sealants. A report of the American Dental Association Council on Scientific Affairs, in the March issue of the *Journal of the American Dental Association*, answers questions regarding the indications for placing pit-and-fissure sealants, the criteria for their placement over early caries, and techniques to optimize retention and effectiveness.

Below is the abstract and a partial list of recommendations/conclusions. For the full report, go to http://jada.ada.org/cgi/reprint/139/3/257.

ABSTRACT

BACKGROUND. This article presents evidence-based clinical recommendations for use of pit-and-fissure sealants developed by an expert panel convened by

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ADA Unveils Ad to Support Dentistry in Developing Countries

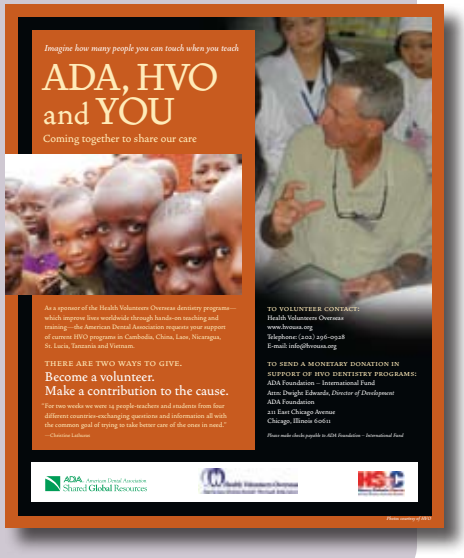
The American Dental Association is offering a camera-ready print public service advertisement to help garner support for the Health Volunteers Overseas Dentistry Programs.

The purpose of the ad, "ADA, HVO and You — Coming together to share our care," is twofold. It seeks financial contributions in support of HVO dentistry programs and it reaches out to dentists to volunteer for the programs.

Currently, volunteer assignments are available for dentists in China, Cambodia, Vietnam, Laos, Tanzania, Nicaragua, and St. Lucia. The assignments can range from one to four weeks.

HVO is a private, nonprofit organization dedicated to improving health care in developing countries through education and training. HVO volunteers travel to resource-poor countries, with an emphasis on educating, clinical training, and increasing the number of local health workers that will benefit the community long after volunteers have departed.

The ADA and its Center for International Development and Affairs is a sponsor of the HVO overseas dentistry program. Dentists interested in learning more about volunteer opportunities can visit www.hvousa.org. Dental publications can download the four-color public service ad at http://www.ada.org/ada/international/volunteer/hvo_ad.pdf.



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New Gel for Treating Pain of TMJ Disorders

Researchers have developed a gel that quickly relieves pain in the temporomandibular joint, myofacial areas, and muscles of mastication. The gel should be administered as a first-step procedure before trying to diagnose and treat the cause of the patient's pain and dysfunction. The study is published in the *Journal of Oral Implantology*.

The gel is composed of 18 percent potassium complex, 10 percent dimethylisosorbide, and 72 percent aqueous hydroxyethyl cellulose gel. As soon as clinicians identify the TMJ disorder, the gel is rubbed onto the facial skin as the authors have found the gel predictably provides immediate relief from pain while accelerating the restoration of the jaw's functional abilities usually within five minutes after application.

The speed of relief from using the gel has led authors to recommend the gel be applied as a first-step procedure before definitive diagnosis and treatment. Once the pain has been eliminated as a complicating factor, a diagnosis and treatment plan regarding the jaw's biomechanical problems may be identified and dealt with.

The gel can be reapplied by the patient as needed, safely providing self-help for comfort control and aiding in the successful treatment of this problem. Topically applied, the gel is odorless, noninvasive, painless, and predictably effective.

Energy Drinks May Boost Dental Erosion

A beverage's "buffering capacity," or the ability to neutralize acid, plays a significant role in the cause of dental erosion.

Energy drinks in the United States, on the upswing over the last decade, have been promising consumers more "oomph" in their day. It is estimated the energy drink market will hit $10 billion by 2010. While great news for energy drink companies, it could mean a different story for consumers.

Previous scientific research findings have helped to warn consumers that the pH levels in beverages such as soda could lead to tooth erosion. The studies revealed that, whether diet or regular, iced tea or root beer, the acidity level in popular beverages that consumers drink every day contributes to the erosion of enamel.

However, in a recent study published in *General Dentistry*, the Academy of General Dentistry's clinical, peer-reviewed journal, the pH level of soft drinks isn't the only factor that causes dental erosion. A beverage's "buffering capacity," or the ability to neutralize acid, plays a significant role in the cause of dental erosion.

The study examined the acidity levels of five popular beverages on the market. The results proved that popular high-energy and sports drinks had the highest mean buffering capacity, resulting in the strongest potential for erosion of enamel.

According to the study, the popularity of energy drinks is ticking upward, especially among adolescents and young adults. Their permanent teeth are more susceptible to attack from the acids found in soft drinks, due to the porous quality of their immature tooth enamel. As a result, there is high potential for erosion among this age group to increase.

Raymond Martin, DDS, MAGD, an AGD spokesperson, said he treats more patients in their teens to 20s for tooth erosion. "They drink a great deal more sodas, sports drinks, and energy drinks," he said. "The results, if not treated early and if extensive, can lead to very severe dental issues that would require full mouth rehabilitation to correct."

To drink responsibly for oral health:

- Use a straw positioned at the back of the mouth so that the liquid avoids the teeth,
- Rinse the mouth with water after drinking acidic beverages, and
- Limit the intake of sodas, sports drinks and energy drinks.

Healthy Gums are Something to Smile About

According to a study published in the *Journal of Periodontology*, a smile may help convey healthy teeth and gums. Researchers found evidence that periodontal disease, or gum disease, may negatively affect an individual's smiling patterns and deter someone from displaying positive emotions through a smile.

The study, conducted at the University of Michigan, evaluated the smiling patterns of 21 periodontal patients while viewing a segment of a comedy program. At predetermined measurement points throughout the segment, the researchers assessed three dimensions of the patients' smile: the horizontal width of the mouth in millimeters, the open width of the mouth in millimeters, and the number of teeth shown. Additionally, the researchers also noted the number of times the patient covered his or her mouth while watching the segment. Individual perceptions of how the patient's quality of life is affected by oral health were also considered. The data then were evaluated along with a clinical exam of the patient's periodontal health.

"Since periodontal disease is prevalent in such a large number of adults, we sought to investigate if the disease affects a person's smiling behavior," said study author Marita R. Inglehart, PhD. "Smiling plays a significant and essential role in overall well-being. Previous findings suggest that smiling can affect social interactions, self-confidence and can influence how people perceive one another."

The findings indicated that periodontal disease can impact how a person smiles. The more symptoms of gum disease found in a patient's mouth, such as periodontal pockets between 4 to 6 millimeters deep, or loose or moving teeth, the more likely the patient was to cover his or her mouth when smiling, or to limit how widely the mouth opened during the smile. Further, the more gum recession seen in the patient, the fewer teeth he or she showed when smiling.

Children's Brain Development Not Adversely Affected by Fillings

Dental amalgam tooth fillings do not adversely affect children's brain development and neurological status, researchers report in a recent issue of the *Journal of the American Dental Association*.

The authors of the report — members of a joint team from the University of Lisbon, Portugal, and the University of Washington, Seattle — studied the possible neurological effects of dental amalgam tooth restorations. Dental amalgam contains elemental mercury combined with other metals such as silver, copper, tin, and zinc to form a safe, stable alloy. Dental amalgam has been used for generations to fill decayed teeth that might otherwise have been lost.

Beginning in 1997 and continuing for seven years, the authors studied 507 Portuguese children aged 8 through 12 years who received either amalgam or resin-based composite fillings. They conducted routine clinical neurological examinations to assess two types of neurological signs: hard (indicating damage to specific neural structures) and soft (subtle signs of central nervous system dysfunction that likely point to immature sensory-motor skills rather than to any structural damage in the brain). The researchers also evaluated the children for presence of tremor.

The two groups of children, after seven years, did not differ in terms of the presence or absence of hard signs or tremor. They also didn't differ in terms of the presence or absence or severity of soft signs at any point. Also, as expected in healthy children, the severity of any neurological soft signs diminished as the children aged.

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There are no findings that bacteria increase under sealants.

California Dental Association Analysis Panel Conclusions

- Reduction of caries incidence after placement of resin-based sealants ranges from 86 percent at one year to 78.6 percent at two years, and 58.6 percent at four years.
- Pit-and-fissure sealants are retained on primary molars at a rate of 74.0 to 96.3 percent at one year, 59 and 70.6 to 76.5 percent at 2.8 years.
- When possible, a four-handed technique should be used for sealant placement.
- Placement of pit-and-fissure sealants significantly reduces the percentage of noncavitated carious lesions that progress for as long as five years after sealant placement.
- There are no findings that bacteria increase under sealants. When placed over existing caries, sealants lower the number of viable bacteria by at least 100-fold and reduce the number of lesions with any viable bacteria by 50 percent.
- Two of three reviewed studies indicate that resin-based sealants are more effective in caries reduction at 24 to 44 months after placement than glass ionomer cement.
- The use of air abrasion instead of acid etching reduces the rate of sealant retention.
- Sealant retention can be improved if the clinician applies a bonding agent that contains both an adhesive and a primer between the previously acid-etched enamel surface and the sealant material.
- Presently available self-etching bonding agents, which do not involve a separate etching step, provide comparable or less retention than do bonding agents that involve a separate acid etching step.

Clinical Recommendation on Pit-and-Fissure Sealant Placement Over Early (Noncavitated) Carious Lesions to Prevent Progression

- Pit-and-fissure sealants should be placed on early (noncavitated) carious lesions to reduce the percentage of lesions that progress.

SEALANTS, CONTINUED FROM 325

the American Dental Association Council on Scientific Affairs. The panel addressed the following clinical questions: Under what circumstances should sealants be placed to prevent caries? Does placing sealants over early (noncavitated) lesions prevent progression of the lesion? Are there conditions that favor the placement of resin-based vs. glass ionomer cement sealants in terms of retention or caries prevention? Are there any techniques that could improve sealants' retention and effectiveness in caries prevention?

TYPES OF STUDIES REVIEWED. Staff of the ADA Division of Science conducted a MEDLINE search to identify systematic reviews and clinical studies published after the identified systematic reviews. At the panel's request, the ADA Division of Science staff conducted additional searches for clinical studies related to specific topics. The Centers for Disease Control and Prevention also provided unpublished systematic reviews that since have been accepted for publication.

RESULTS. The expert panel developed clinical recommendations for each clinical question. The panel concluded that sealants are effective in caries prevention and that sealants can prevent the progression of early noncavitated carious lesions.

CLINICAL IMPLICATIONS. These recommendations are presented as a resource to be considered in the clinical decision-making process. As part of the evidence-based approach to care, these clinical recommendations should be integrated with the practitioner's professional judgment and the patient's needs and preferences. The evidence indicates that sealants can be used effectively to prevent the initiation and progression of dental caries.

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UPCOMING MEETINGS

2008	
May 1-4	CDA Spring Scientific Session, Anaheim, 800-CDA-SMILE (232-7645), cda.org.
May 2-3	Evidence-based Dentistry Champion Conference, ADA headquarters, Chicago, ada.org/goto/ebdconf.
May 4	International Conference on Evidence-based Dentistry, ADA headquarters, Chicago, ada.org/goto/ebdconf.
May 6–9	Conference for Oral Health in the Americas, Lima, Peru, http://www.fdiworldental.org/public_health/3_1conferences.html.
July 16-20	56th Annual Meeting and Exhibits, Academy of General Dentistry, www.agd2008orlando.org.
Sept. 12-14	CDA Fall Scientific Session, San Francisco, 800-CDA-SMILE (232-7645), cda.org.
Sept. 24-27	FDI Annual World Dental Congress, Stockholm, congress@fdiworldental.org.
Oct. 16-19	American Dental Association 149th Annual Session, San Antonio, Texas, ada.org.
Oct. 25-29	American Public Health Association Oral Health Section's annual meeting and exposition, San Diego, www.apha.org/meetings.
2009	
May 14-17	CDA Spring Scientific Session, Anaheim, 800-CDA-SMILE (232-7645), cda.org.
Sept. 11-13	CDA Fall Scientific Session, San Francisco, 800-CDA-SMILE (232-7645), cda.org.
Oct. 1-4	American Dental Association 150th Annual Session, Honolulu, Hawaii, ada.org.

To have an event included on this list of nonprofit association continuing education meetings, please send the information to Upcoming Meetings, CDA Journal, 1201 K St., 16th Floor, Sacramento, CA 95814 or fax the information to 916-554-5962.

Honors

Eugene LaBarre, DMD, MS, of Alameda, Calif., associate professor and chair of the Department of Removable Prosthodontics at the Arthur A. Dugoni School of Dentistry, is a recipient of the 2008 Medallion of Distinction. The award is the highest honor the dental school Alumni Association can bestow upon an individual.

Eugene LaBarre, DMD, MS

Population-based Evaluation of Antenatal Diagnosis of Orofacial Clefts

In trying to evaluate whether there have been any changes in the prevalence or antenatal detection of clefts, while researchers have found no change in prevalence of the Nova Scotia population they do cite improved detection. Their study is published in the latest issue of *The Cleft Palate — Craniofacial Journal.*

Affecting nearly 7,000 children each year, or 1 in every 600 newborns, clefts are the most frequent birth defect in the United States. They may be visible by diagnostic imaging techniques as early as the first trimester, when fusion of the facial prominences and palatal shelves occurs. For several decades, clefts of the lip and primary palate have been diagnosed antenatally with 2-D ultrasonography.

In the study, 225 fetuses were identified as having orofacial clefts. The overall prevalence of clefts was 2.1 in 1,000 live births, and this prevalence did not change with time. The overall antenatal detection of cleft lip with or without cleft palate was 23 percent. However, there was improvement in detection of cleft lip with or without cleft palate from the years 1992 to 1996 (14 percent) to the years 1997 to 2002 (30 percent). No isolated cleft palates were detected antenatally.

To read the entire study, go to http://www.allenpress.com/pdf/CPCJ45-2-article.pdf.

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Elements *of the* Smile

ZIV SIMON, DMD, MSC

GUEST EDITOR

Ziv Simon, DMD, MSC, is a diplomate of the American Board of Periodontology and a fellow of the Royal College of Dentists in Canada. He lectures and publishes on tissue reconstruction, implant dentistry, and esthetic periodontal surgery. He also maintains a private practice limited to periodontics and reconstructive surgery in Beverly Hills, Calif.

It is an honor to edit this special edition involving the elements of the smile. I was fortunate to collaborate with great clinicians who contributed manuscripts and were able to share their wealth of knowledge in the different disciplines of dentistry.

A smile is made up of elements like lips, dentition, and gingivae. When all elements are joined in the appropriate proportions, they act in synergy to create a beautiful smile. In order to successfully treat complex cases we need to understand the principles of esthetics such as symmetry, dominance, composition, and repeated ratios. These have been used for thousands of years by architects, mathematicians, and artists. We, dentists, need to work under all of the latter capacities to provide our patients with the pleasing esthetic outcome they desire.

An interdisciplinary comprehensive approach to diagnosis, treatment planning, and the active phase of treatment is essential and is demonstrated in this issue's articles. I hope you will find this edition informative and useful in your practice, and that it will help you achieve esthetic and predictable results for your patients.

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Creating the Perfect Smile: Prosthetic Considerations and Procedures for Optimal Dentofacial Esthetics

AVI DONITZA, DMD

ABSTRACT Creating the perfect smile and individual esthetics is a challenging procedure that requires a multidisciplinary approach and meticulous treatment planning. Since esthetics is subjective and depends upon the patient and the clinician perception, it is difficult to obtain specific guidelines or a systematic approach that will lead to consistent results. This article discusses several guidelines that have been proposed to help clinicians in the process of creating esthetic appearance and their applications in esthetic dentistry.

AUTHOR

Avi Donitza, DMD, practices prosthodontics and maxillofacial prosthetics, in Beverly Hills, Calif.

ACKNOWLEDGMENT

The author would like to thank Dr. Stephen Marquardt for his help in writing this article.

Achieving esthetic restorations that are in harmony with the patient's facial contours and appearance is one of the most difficult tasks in prosthodontics.

In the process of providing esthetic treatment for a patient, one relies on one's eyes and personal perception of beauty, as well as guided by the patient's desires, and limited by anatomical and occlusal variables.

What makes a person attractive? Many studies suggest beauty is characterized by balance: The more symmetrical a face, the more appealing it appears. This principle also applies to the body: A symmetrical body is subconsciously perceived by others as a sign of youth, health, and strength.[1]

Symmetry is sexy, too. Studies of hundreds of college-age women and men revealed that men who look more symmetrical started having sex three to four years earlier and had more sex partners than their asymmetrical peers.[2] A different study found that women prefer the scent of symmetrical men and vice versa.[3]

Several formulae and geometric proportions have been proposed to help the clinician achieve facial harmony and esthetics. Few of them have been proven to be very useful in detection of esthetic problems when one's eyes cannot:

- The width of the maxillary central incisor has been related through average measurements to the bizygomatic width (1:16) and to the interpupillary distance (1:6.6).[4,5]
- The interalar width was related to the distance between the canines.

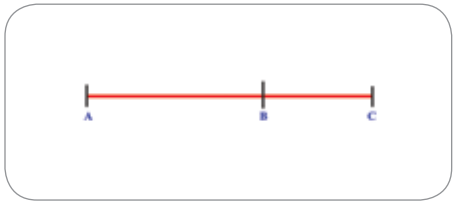

FIGURE 1. Linear golden ratio.

FIGURE 2. Parthenon.

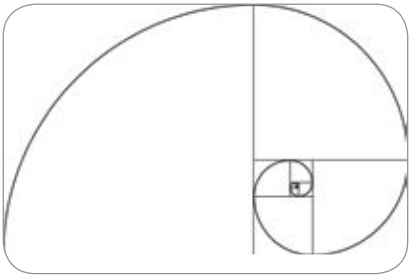

FIGURE 3. Development of seashell.

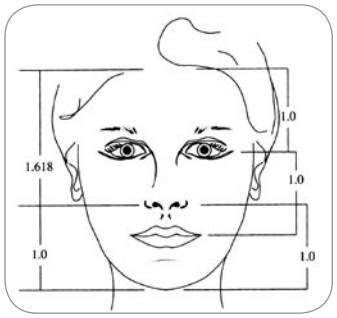

FIGURE 4. Measurements in the vertical aspect.

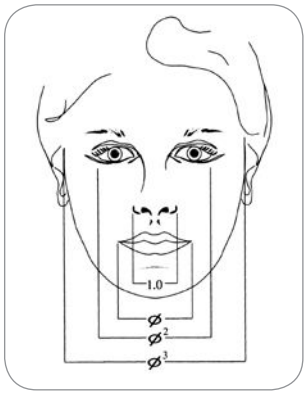

FIGURE 5. Measurements in the horizontal aspect.

FIGURE 6. Golden ruler.

Several studies have found that these relationships exist more in women, and change with racial differences.[6,7] The large variability of these measurements limits their application in esthetic dentistry and may be used as an initial guide only in the process of smile evaluation.

The golden proportion (1.00:1.618) was first described by Aristotle in ancient Greece and is thought to hold the secret of beauty by many artists, scientists and architects. Leonardo Fibonacci described the mathematical relationship behind the golden proportion in the 12th century. Starting with zero and one, each new number in the series is the sum of the previous two: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89 ...

The ratio between each successive number in the series quickly converges on Phi, or as it called: the golden proportion. After the 40th number in the series, the ratio is accurate to the 15th decimal place: 1.618033988749895 ...

FIGURE 1 shows the proportion in its simplest linear form: The line A-C is divided by B according to the golden proportion, so A-B is 1.618 times larger than B-C. The proportion of the smaller part to the greater is the same as the proportion of the greater to the whole.

The golden proportion appears as a geometric reference in creating perceived esthetics. Artwork and architectural structures throughout history, that incorporate geometrical configurations based on the golden proportion, are often perceived as attractive and beautiful. **FIGURE 2** shows the incorporation of the golden proportions in the constructions of the Parthenon in ancient Greece. It is an integral part in the architecture and drawings of Leonardo da Vinci, Sir Christopher Wren, Le Corbusier, and more.

The proportion is observed throughout nature in animals, plants, and the solar system. **FIGURE 3** is an example of golden proportion in the structure of seashells. It is also observed in the human body, in the configuration of the human DNA, and between components of the human face.

FIGURES 4 AND 5 demonstrate craniofacial analysis in the frontal view and the golden proportion between variable parts of the human face.[8,9]

Applying the rule of the golden proportion to the widths of the anterior teeth as viewed in the frontal plane will help create an esthetic and pleasing smile: The perceived width of a tooth should be approximately 62 percent of the width of the mesial tooth in order to be esthetically pleasing. The width of the central relates to the width of the lateral, the lateral to the canine, and the canine to the first bicuspid. It must be clear that the golden proportion rule does not apply to the actual width measurements of the teeth but to the way they are perceived when viewed from the front.

Several instruments, based on the golden proportion, have been manufactured by different companies as an aid for dentists and other professionals in evaluating facial appearance and designing esthetic restorations:

The golden ruler (Panadent Corp.,

FIGURE 7. Diagnostic wax-up with golden ruler.

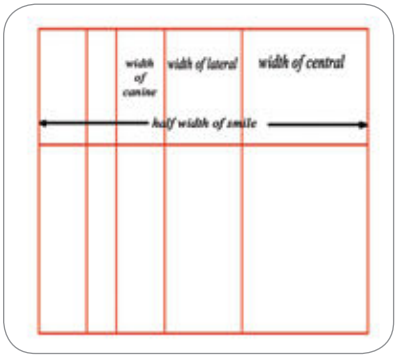

FIGURE 8. Golden grid.

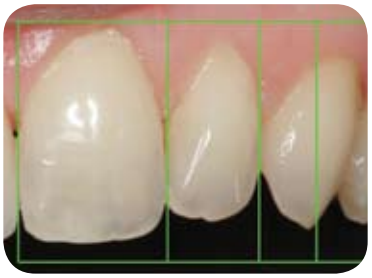

FIGURE 9. Esthetic appearance that does not follow the golden proportion rules.

Grand Terrace, Calif.) and the golden mean gauge (www.goldenmeangauge.co.uk) are three-arm instruments that maintain the spacing of the arms at the golden ratio at any opening (**FIGURE 6**). These instruments allow the dentist to evaluate the patient's facial proportions directly on the patient's face and compare it to the "ideal" measurements represented in **FIGURES 4 AND 5**. They also help in the design of the diagnostic wax-up and the final restorations of the anterior teeth (**FIGURE 7**).

■ The golden proportion waxing guide (Panadent) is a grid of lines spaced by the golden ratio according to the width of the central incisors. The set includes seven guides ranging from 7 – 10 mm in 0.5 mm increments, to correspond to the width of one central incisor. After deciding the width of the central incisor, the clinician or the technician can wax the remaining anterior teeth to achieve an esthetic result that embodies the golden proportionate spacing. A simple grid that can be prepared by the clinician is presented in **FIGURE 8**.

■ Meisner (www.goldennumber.net, www.phimatrix.com, www.phidental.com) developed the PhiMatrix, software that helps in the analysis of tooth size using digital pictures. The software is based on the grids developed by Levin and creates a horizontally and vertically golden proportion grid that can be superimposed on a digital picture.[10]

Snow discussed the limitations of the golden proportion and questions its validity: Applying the golden proportion rules unilaterally (the central to the lateral to the canine) does not analyze symmetry. If the two lateral incisors are different in width, the application of the golden proportion will create different widths for the central incisors. He proposed the "Golden Percentage" as a more useful analysis tool. The golden percentage describes the contribution of each tooth to the overall width between the canines. Each central incisor contributes 25 percent of the width, the lateral incisors contribute 15 percent, and the canines 10 percent each.[11] Applying the golden percentage rules on a frontal picture of a smile identifies and quantifies asymmetry of the entire anterior segment, allowing for a more accurate smile design.

Snow also explains the influence of the arch form on the perceived relative width of the anterior teeth. A wider arch form will display more of the canine width in a frontal view and the teeth relative widths will deviate from the golden percentage or the golden proportion rules.[11] **FIGURE 9** illustrates this limitation in the application of the golden proportion. Although the width of the canine does not fit the superimposed grid, the appearance of the teeth is pleasing.

The arrangement or sizing of teeth based upon certain facial measurements or set proportions should be used carefully and only as an initial guide for the width and position of the incisors and canines.

Each patient is different, and any decisions based on any instrumentation should be evaluated and tested directly on the patient by means of diagnostic wax-up, temporary restorations, phonetics, and occlusal considerations.

The next important procedures in the process of creating a perfect smile are proper mounting of the patient's models in the articulator and the diagnostic wax-up.

Mounting the Models

The mounted casts should represent the anatomical position of the patient's teeth in relation to reference points. The human eye judges objects and their relationship to the horizontal and vertical or to deviation from these planes. Therefore, it is easy to establish an esthetic baseline by having the esthetic plane of occlusion parallel to the horizon. Traditionally, dentists are taught to record the incisal-canine line parallel to the eyes and use the ear rods of the facebow as the posterior reference points. Since people's facial features are asymmetrical, when the eyes or ears are slanted, the registration would orient the models in the articulator slanted in the same degree. Therefore, it is important to register the position of the teeth in relation to the horizontal plane and transfer the records to the articulator.

Lee created the Bioesthetic Level Gauge and the Adjustable Nasion Relator facebow that are used with the Panadent system.[12,13] The system uses a magnetic level gauge that can be posi-

FIGURE 10A. Patient's existing teeth.

FIGURE 10B. Mounted casts.

FIGURE 10C. Diagnostic wax-up.

FIGURE 10D. Clear acrylic resin stent.

FIGURE 10E. Acrylic stent on patient's teeth at start of crown lengthening.

FIGURE 10F. Crown lengthening completed.

FIGURE 10G. Final restorations.

tioned anterior-posterior in the sagittal plane of the facebow, and in the frontal plane along the incisal-canine direction. Transferring the bite fork assembly to the articulator will orient the maxillary arch in correct relation to the horizontal plane.

The Kois Dento-Facial Analyzer System (Panadent) uses the same principles in a simplified facebow that registers the patient's occlusal plane. It is oriented to the patient's midsagittal in the frontal plane, with the bite fork parallel to the horizon from the profile view. The record is then transferred to the articulator and mounted on an adjustable platform. After mounting, the Kois system uses waxing guides that fit over the platform with marked grids based on the golden proportion. As mentioned before, these grids are used for the diagnostic wax-up and help create a proportional, esthetic smile.

The Diagnostic Wax-up

The diagnostic wax-up is next in the planning process. This is the only way one can preview the desired esthetic appearance. The diagnostic wax-up provides guidelines of the needed treatment and a blueprint of the final restorations. A diagnostic wax-up is a necessity for every treatment, from single tooth restoration to full mouth rehabilitation.

It is important to remember, however, that creating the diagnostic wax-up with an idealized configuration dictated by anatomical determinants alone (such as the retromolar pad, commisure of the mouth, Frankfurt horizontal plane, etc.) may lead to suboptimal facial esthetics. It is important to relate the diagnostic wax-up directly onto the patient's teeth in order to evaluate the facial esthetics. This can be done in several ways:

- If restoration of the vertical dimension is needed due to loss of tooth structure, an initial flat stabilization splint can be useful. The splint thickness will restore the patient's VD in the same amount that was created with the diagnostic wax-up. This will help in evaluating the new lower facial height and overall facial appearance before undertaking any irreversible procedures. The bite splint is also useful for evaluating the ability of the patient's musculature to accommodate the new vertical dimension.
- When shortened anterior teeth need augmentation of the incisal aspect, crown lengthening on the gingival aspect, or combination of both, it would be helpful to evaluate the desired teeth length before the actual procedures are performed.

Spear described three methods for evaluating and placing the incisal edge of the central incisor:[14]

1. Evaluation of the central incisal edge relative to the other teeth in the maxillary arch. In a normal class I occlusion the incisal edge of the central will be approximately on the same plane as the tip of the canines and the buccal cusp tips of the premolars and molars.
2. Phonetics — pronouncing of "V" and "F" sounds should create a light contact between the central incisor and the "wet-dry" line of the lower lip. This method is more useful to determine if the patient's teeth are too long. Usually, even with severely worn teeth, the "F" and "V" sounds look correct.
3. Evaluation of the amount of tooth

displayed at rest and lip mobility that occur in a smile. First, evaluate how much of the tooth is exposed when the upper lip is at rest. Then evaluate how many millimeters the lip moves at smile. Knowing the length of an average central (approx. 10.5 mm) and how much tooth the patient would like to show in a smile will help determine the incisal edge position.

These methods provide only a starting point in the diagnosis and guidelines for the optimal diagnostic wax-up. By duplicating the diagnostic wax-up in stone one can obtain a clear matrix of the wax-up made of a clear splint material (Proform 0.08-inch splint material; Dental Resources, Delano, Minn.) and a vacuum machine (UltraVac Vacuum Former; Ultradent Products). The matrix is then filled with acrylic or composite resin and adapted on the model of the patient's existing teeth. This will create a thin resin shell that will fit over the patient's existing anterior teeth. The shell provides an excellent tool for evaluation of facial appearance, length of the anterior teeth in relation to a full smile and in rest, correlation of the anterior teeth with the lower lip and the midline position.

FIGURES 10A-G demonstrate periodontal and prosthetic procedures for the restoration of severely worn anterior teeth.

FIGURE 10A shows the patient's existing teeth, a 45-year-old male with severe wear of the maxillary anterior teeth. Evaluation of the patient's incisal edge position was made according to the guidelines discussed above and indicated a need for lengthening of the incisal edge in approximately 1.5 mm. High lip line and the display of gingival tissue during smile indicated the need for a crown lengthening procedure of the anterior segment. These procedures will create anterior teeth with normal length and amount of tooth display that would fit the patient's desire.

The patient's models were mounted on a semi-adjustable articulator, ac-

FIGURE 11A. Patient pretreatment.

FIGURE 11B. Mounted diagnostic wax-up.

FIGURE 11C. Final restorations.

cording to the principles discussed earlier (**FIGURE 10B**) and marked for the desired gingival height. The diagnostic wax-up was created (**FIGURE 10C**). The wax-up was duplicated in stone and a vacuum made clear matrix was made as described above. The matrix was filled with cold-cure clear acrylic resin and fitted on a model of the patient's existing teeth. The result, as shown in **FIGURE 10D**, was a thin shell of clear acrylic resin that included the desired additional incisal and gingival lengths and would fit over the patient's existing teeth. **FIGURE 10E** shows the application of the acrylic stent during the periodontal procedure. Eight weeks later, the tissue is healthy and esthetically contoured (**FIGURE 10F**) and the patient is ready to continue with the prosthetic phase. Six porcelain-fused to metal crowns were fabricated and delivered (**FIGURE 10G**).

FIGURE 11A represents a 46-year-old female who presented for esthetic consultation and treatment. After evaluation of the occlusion and the posterior dentition, parafunctional habits, periodontal condition and the patient expectations, a smile evaluation was performed. There was no need for incisal edge lengthening. Although the patient did not show the cervical part of her teeth while smiling, she requested to improve the gingival contour around her anterior teeth. The treatment plan included periodontal procedures to cover the exposed root surfaces and to achieve an esthetic contour of the gingival margins and 16 porcelain veneers on the anterior teeth.

The models were mounted and the diagnostic wax-up was created (**FIGURE 11B**) with ideal teeth height and gingival contour. A clear acrylic resin matrix was made over a stone duplicate of the diagnostic wax-up. The matrix was carefully trimmed around the gingival margin of the anterior teeth to provide a guide for the periodontist in reshaping the gingival tissue and adding attached tissue over the two laterals for best esthetics. After healing and completion of the prosthetic treatment the final results are presented in **FIGURE 11C**.

Summary

As clinicians, one strives to provide a final result that would fulfill the patient's desires, in harmony with the patient's anatomical structure, and will provide the patients with many years of service.

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It is a common knowledge that beauty and esthetics are subjective and differ between cultures and geographic locations. This article discussed several methods and techniques that may help the clinician and provide an initial guide for the creation of individual esthetic restorations. ■■■■

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Simple Techniques for Optimal Smile Modification

RAFI ROMANO, DMD, MSC

ABSTRACT Orthodontics is no longer a treatment modality for moderate or severe malocclusion. Patients of all age groups seek help in tooth repositioning. Esthetic demands are extremely high and clinicians need to be more creative and more open to alternative techniques that will suit the demand for invisible treatment, at reasonable costs, maximum accuracy, and with relative comfort. A few simple techniques are described for very common orthodontic problems.

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Although the smile has been the focus of all dental practitioners for many years, it has been investigated and discussed more extensively in the last decade. Techniques such as power bleaching and porcelain and composite veneers are part of almost every esthetic treatment.[1,2]

Orthodontics has focused on its foundations in measuring the entire craniofacial complex trying to achieve the optimal jaws and teeth position regardless of the outcome in terms of esthetic proportions.[3]

A smile is defined and described differently by orthodontists.[4-6] These definitions were modified by prosthodontists and periodontists who realized that the smile can easily be altered and improved by simple procedures that will supplement the orthodontic movements, and plastic surgeons added more parameters related to aging, gravity effects on the face and lip muscles, continuous growth of the nose, and the diminished soft tissue and bony volumes.[7-9]

Fashion and beauty magazines and commercials frequently ignore the parameters that dental clinicians considered of the highest importance, as long as harmony is preserved. Yet, looking closely at most fashion models, many imperfections are observed such as misaligned teeth, enlarged overjet, uneven incisal edges, and midline deviations. A clinical study that compares the perception of dentists and lay people to altered dental esthetics demonstrated there is a tendency to ignore minor imperfection as long as it does not jeopardize the harmony of the smile.[10]

This article will present dental clinicians with a few simple techniques that facilitate the enhancement of the esthetics of the smile improvement.

FIGURE 1A. Frontal view of the patient's smile. Note the black corridors due to the constricted arch and the lack of anterior papilla due to the opened diastema.

FIGURE 1B. Frontal view.

FIGURE 1C. Maxillary occlusal view.

FIGURE 1D. Lateral view, note occlusal contacts.

FIGURE 1E. Patient with the Invisalign on both arches. Note the esthetic appearance even from a close-up view.

FIGURE 1F. Frontal view of the final result. Note the harmony of the arch shape and the gingival architecture.

Arch Expansion

Expanding the posterior segments of both upper and lower arches has tremendous effects on the smile. The black corridors created by a narrow and triangular arch can easily be modified by merely changing the torque of the posterior teeth. Andrews defined negative torque values to his straight wire brackets, which caused a very unesthetic appearance.[10] Expansion can be done by various techniques like rapid maxillary expansion, quad-helix, regular or self-ligating braces, and more. The Invisalign technique has been found to be the most predictable and accurate.

While closing spaces caused by spaced dentition or by extractions, the arch tends to narrow; arch coordination is not easily monitored with the edgewise technique, and the expansion tends to relapse quite fast after the debonding due to poor cooperation of the patient who is requested to wear vacuum-form retainers for nights over a long time. Patients treated with the Invisalign technique will become accustomed to the appliance during the treatment and will better accept the same type of appliance for retention.

FIGURES 1A-F show the usage of the Invisalign technique to expand the maxilla and to close anterior diastema. The 3-D model enables one to forecast the shape of the maxilla and the relation to the opposing arch in a close-up view and check all, not only the esthetic parameters but also the occlusal factors (**FIGURE 1D**). Stability of arch expansion is a subject of debate between clinicians.[12] Yet, the current tendency of long to lifetime retention of the orthodontic end result with vacuum retainers for nightwear and/or fixed bonded retainers will definitely guarantee long-term stability.

Expansion also is easily performed with lingual orthodontics when the bite plane is used to eliminate any posterior interference. **FIGURES 2A-E** demonstrate the use of a lingual appliance (Ormco, Kurz Generation 7) to expand the arch and give it a rounder shape. Indirect bonding techniques enable the clinicians to plan the teeth's exact final required positions and to achieve the highest standards of smile design.

Incisal Edges and Gingival Height Control

Many clinical cases face the problem of uneven incisal edges or gingival height discrepancies. A simple method to solve this problem is described in **FIGURES 3A-F**. Patient is 29 years of age, with tooth No. 11 shorter than No. 21. The gingival level is also higher. Treatment options were to shorten tooth No. 21 (**FIGURE 4D**), which was rejected by the patient and not highly recommended by the author due to the low upper lip line and the limited exposure of upper incisors during smiling. Composite restoration was not chosen since the preparation had to be extensive to provide enough retention.

The patient preferred the forced eruption option for tooth No. 11 with an esthetic invisible appliance. Invisalign and lingual orthodontics could have been a good option, yet the mechanical limitations of Invisalign (extrusion movements are the most difficult for clear aligners) and lingual orthodontics (which would have required posterior bite blocks to open the deep

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FIGURE 2A. Occlusal view of patient with constricted maxilla and misaligned teeth.

FIGURE 2B. Maxillary occlusal view of patient with constricted maxilla and misaligned teeth.

FIGURE 2C. Occlusal view of the maxilla with the lingual appliance. Note the bite plane integrated in the Ormco Kurz Generation 7 brackets that enable anterior bite opening and elimination of posterior occlusal contacts to achieve rapid and efficient expansion.

FIGURE 2D. Occlusal view of patient at debonding of braces.

FIGURE 2E. Frontal view of smile on completion of treatment.

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bite and enable the extrusion movement) as well as the cost involved, left these options as a last solution. Clear braces were also not accepted by the patient due to their limited esthetics.

Coated nickel titanium wire was bonded to teeth Nos. 12 and 21 and the wire was then "pulled" upward and bonded on tooth No. 11 (**FIGURE 3D**). Three weeks later, the tooth leveled with the adjacent tooth and the gingival level has improved as well (**FIGURES 3E-F**). A fixed bonded retainer was used to retain the results at minimal cost to the patient.

Minimal to Mild Crowding

Class I crowding is the most common malocclusion. The treatment plan for the anterior six teeth is a target of almost any esthetic dentist who is concerned with the limited reconstruction options that one might have if he were to skip the alignment of the teeth prior to any esthetic treatment modality such as crowns, veneers or composite restorations. Treatment options in misaligned anterior teeth can also be to cover them with veneers, but the excessive amount of tooth material needed to be removed in order to achieve a harmonious arch shape, the risk of loss of the vitality of the teeth together with the great costs involved in such treatment modality, renders this option as low in priority. **FIGURES 4A-G** show a typical case that demonstrates these conflicts. Tooth No. 21 needed an esthetic restoration. Teeth Nos. 12 and 22 were buccally inclined and teeth Nos. 11 and 21 were retroclined (**FIGURES 4A-B**) The treatment plan included buccal movement of the upper central incisors in order to place them in a broader arch, which will contribute not only to the shape of the arch but will also gain space needed to solve the mild crowding. Minimal interproximal reduction was performed to gain the remaining necessary space.

A cast model was trimmed in the mesio-buccal aspect of teeth Nos. 12 and 22 to create palatal and rotation force vector (**FIGURE 4B**) and a ball-shaped hole was trimmed on the midpalatal aspect of teeth Nos. 11 and 21 to create buccal force vector. Pink wax (or flowable composite) was attached to the opposite side of the planned pressure points in order to enable the teeth movement (**FIGURE 4C**). Attention should be paid not to release the part of the tooth that one does not wish to move (such as the disto-palatal aspect of teeth Nos. 12 and 22).

Clear aligners (Raintree Essix), were used to correct the malocclusion (**FIGURE 4D**). The clear aligner is worn 22 hours a day for two to three weeks, and it is then replaced with an additional one, which is also made in-office with a vacuum former at minimal cost. Esthetics was preserved throughout the whole treatment. Five months after treatment was initiated with seven aligners in total (**FIGURES 4E-G**), the patient was referred to the prosthodontist to complete the esthetic restoration of tooth No. 21.

Periodontal Cases

A smile is often affected by a poor periodontal condition, with diminished bone support that eventually contributes to the teeth buccal migration with spaces opening. Tongue thrust habits can aggravate the already buccally inclined teeth. **FIGURES 5A-H** demonstrate a case in which lower incisors migrated forward with 4 mm medial diastema. The enlarged space with poor oral hygiene caused loss of the interdental papillae. Anterior lower teeth had mobility

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FIGURE 3A. Frontal view of the smile showing the uneven incisal edges between teeth Nos. 11 and 21.

FIGURE 3B. Maxillary occlusal view showing the uneven gingival level of teeth Nos. 11 and 21.

FIGURE 3C. Figure was modified by shortening the incisal edge on tooth No. 21. Although incisal edges are leveled, gingival level is still unesthetic.

FIGURE 3D. Coated nickel titanium wire was bonded to teeth No. 12 and No. 21 and then the wire was "pulled" upward and bonded on tooth No. 11.

FIGURE 3E. Frontal view of the smile at debonding showing harmonious smile.

FIGURE 3F. Frontal view of the occlusion at debonding showing even incisal edges and acceptable gingival level.

FIGURE 4A. Various views of the patient's smile and occlusion. Note the buccal inclination of teeth Nos. 12 and 22 and the retroclination of teeth Nos. 11 and 21.

FIGURE 4B. Cast model was trimmed in the mesio-buccal aspect of teeth Nos. 12 and 22 to create palatal and rotation force vector and a ball-shape whole was trimmed on the midpalatal aspect of teeth Nos. 11 and 21 to create buccal force vector.

FIGURE 4C. Pink wax (or flowable composite) was attached to the opposite side of the planned pressure points in order to enable the teeth movement.

FIGURE 4D. Clear aligners (Raintree Essix) were used to correct the malocclusion.

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stage II. The smile became very unattractive (**FIGURE 5A**). Radiographic records showed minimal bone support for teeth Nos. 32-42 of less than 4 mm (**FIGURES 5B-C**) and proclination of the lower incisors with protuberance and curling of the lower lip (**FIGURE 5D**). Treatment options included extraction of teeth Nos. 31 and 41 to be replaced by implant-supported restorations, fixed bridge restoration with wide, enlarged, anterior incisors, or orthodontic treatment. The patient and referring dentist were afraid the diminished bone support and the teeth mobility, together with a space of almost a tooth width, would minimize the prognosis of the orthodontic treatment and aggravate the periodontal disease. Since the literature and the author's own experience did not support this theory, it was decided to close all spaces by means of small, continuous forces and fixation of the teeth with fixed braces, which immediately prevented the trauma to the bone caused by the mobility of the teeth and the traumatic contacts with the opposite arch[13] (**FIGURES 5 E-H**).

Clear braces (Forestadent Brilliant series) were used to align upper and lower

FIGURE 4E. Occlusal view of the maxilla at the end of treatment. Total treatment time was five months with seven sequential clear aligners.

FIGURE 4F. Frontal view of the smile at the end of treatment before reconstruction of tooth No. 21.

FIGURE 4G. Profile view of the face during smile at the end of treatment. Note the esthetic emergence profile of the anterior teeth showing that no proclination was performed.

FIGURE 5A. Various views of the patient's smile and occlusion. Note the proclination of the lower anterior teeth with very big diastema between the lower central incisors, which also created loss of the papilla and unesthetic smile.

FIGURE 5B. Panoramic radiograph showing the minimal bone support for the anterior lower incisors. Shortening of the teeth length is due to their proclination.

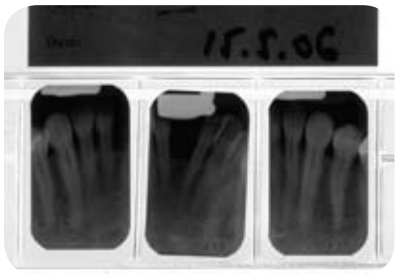

FIGURE 5C. Periapical radiographs showing around one-third bone support for the roots of the anterior lower incisors.

FIGURE 5D. Cephalometric radiograph showing the proclination of the anterior lower incisors.

FIGURE 5E. Various views of the patient's smile and occlusion. Note the great improvement in the overall esthetics of the smile. Fixed bonded retainers together with vacuum form for nights were used to retain the result.

teeth with minimal force application and monthly hygiene control. Twelve months later, braces were debonded and teeth were fixed with a bonded retainer (3-3) and a vacuum retainer for nights. Although the overjet was enlarged, the overall esthetics was tremendously improved, bone support was increased by more than 100 percent, and the central papilla grew to a normal shape and texture.

Clear aligners such as Invisalign are a good treatment choice when periodontal disease is spread to a greater extent and the anchorage value of the posterior teeth is relatively poor, as shown in **FIGURES 6A-D.** The splint of the arch with the vacuum retainer provides stability to the already mobile teeth and enables the clinician to control the level of the forces and the flow of the treatment more carefully. ■■■■

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FIGURE 5F. Cephalometric radiograph at the end of treatment showing the correction of the inclination of the proclined.

FIGURE 5G. Panoramic radiograph at the end of treatment showing parallel inclination of the lower anterior incisors and augmentation of the bone surrounding the root surface.

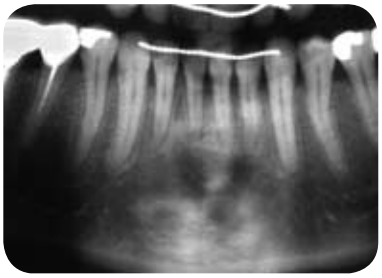

FIGURE 5H. Periapical radiographs at the end of treatment showing the augmentation of bone in the lower anterior region and the optimal conditions for papillas reconstruction.

FIGURE 6A. Frontal occlusal view showing the complex malocclusion and extensive attrition, which frequently present in adult patients. Mobility in stages I-II and diminished bony support decrease the anchorage value of the teeth.

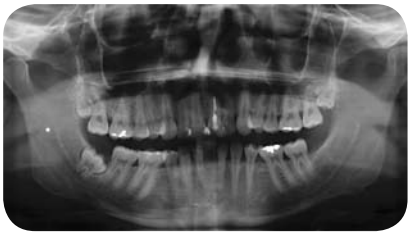

FIGURE 6B. Panoramic radiograph showing the poor periodontal condition with minimal to moderate bone support. Note also the inclination of the premolars caused by orthodontic extraction at early age and unsuccessful treatment following these extractions.

FIGURE 6C. Frontal occlusal view of the Invisalign that was used not only to move the teeth in more controllable method but also to stabilize the mobile teeth while orthodontic movements were performed.

FIGURE 6D. Mandibular occlusal view of the Invisalign appliance. Note the full accurate coverage of the whole aspects of the teeth and the esthetic pontic that was used in the anterior region as a temporary restoration until spaces opened properly for implant restorations.

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Clinically Based Diagnostic Wax-up for Optimal Esthetics: The Diagnostic Mock-up

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ABSTRACT A diagnostic wax-up can enhance the predictability of treatment by modeling the desired result in wax prior to treatment. It is critical to correlate the wax-up to the patient to avoid a result that appears optimal on the casts but does not correspond to the patient's smile. This article reviews the applications and techniques for clinically based diagnostic wax-up, and focuses on the diagnostic mock-up philosophy as a means to obtain predictable esthetics and function.

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Obtaining a predictable esthetic result is one of the goals of prosthodontic and restorative dental treatment. Esthetic and functional treatment outcomes should be known prior to placement of a definitive restoration. Respecting this principle will prevent major disappointments and unnecessary remakes.[1] A diagnostic wax-up has been advocated to enhance the predictability of the treatment.[2-5]

Definition

A diagnostic wax-up is defined by the glossary of prosthodontic terms as a dental diagnostic procedure in which planned restorations are developed in wax on a diagnostic cast to determine optimal clinical and laboratory procedures necessary to achieve the desired esthetics and function.[6] The result of this process, the wax-up, is a 3-D model of teeth built in wax that represent the desired contours of the teeth to be restored.

Applications

The diagnostic wax-up is a tool that can be used for diagnosis and treatment of dentate patients, partially edentulous, and completely edentulous patients using wax or denture teeth set in wax as media.[7] This tool can provide important diagnostic information that will indicate the need for a specific treatment.[2,8] It can assist in the selection of proper restoration and determine the need for preprosthetic surgery, periodontal, orthodontic, or endodontic treatment. The wax-up can assist in estimating the amount of restorative space available and point out any need for treatment in the opposing arch to obtain such space. It can help in evaluating the planned occlusal scheme

and indicate which modifications are needed in the remaining dentition.[9]

A well-made diagnostic wax-up can be used as means of communication between the clinician, the technician, and the patient illustrating the tentative plan three-dimensionally and allowing modifications in a reversible way.[10,11] It can be used as a patient education tool and as means to facilitate acceptance and approval of indicated treatment.[5-7]

The diagnostic wax-up can also be utilized as a treatment tool. In edentulous spaces, the diagnostic wax-up can be used to form radiographic and surgical implant placement guides. In fixed prosthodontics it can be used to make a tooth preparation guide creating a vacuum-formed template or silicone matrix from the wax-up. This will guide tooth reduction according to the contours prescribed by the wax-up.[2,8,12-14] This type of matrix can be used subsequently to create a provisional restoration based on the wax-up.[2,8,12,13] This provisional restoration will be a prototype of the definitive restoration testing the design established by the wax-up.

While a fixed provisional restoration can be used over a period of time to evaluate esthetics and function, a provisional restoration for porcelain veneers has a short life span due to limited retention and is consequently not well suited for that purpose. Furthermore, preparations for porcelain veneers, unlike conventional crowns, should ideally be less than 1 mm thick to preserve as much enamel and remaining tooth structure as possible. Such precision can be achieved when the exact contours of the definitive restoration are known prior to tooth preparation. Therefore, patients undergoing porcelain veneer treatment will require meticulous evaluation prior to the preparation and provisionalization stage.[15,16]

It is important to differentiate between a diagnostic wax-up of individual teeth in an arch of properly positioned teeth to one made for an arch of malpositioned teeth. In the first case the teeth to be restored simply need to be shaped in wax while the remaining teeth act as a guide. In the second case, the remaining teeth may be worn down, supraerupted or malpositioned, and in order to design the wax-up of the teeth to be restored, the correct position of the remaining teeth needs to be re-established. In fact, the process of making a diagnostic wax-up in the latter case may indicate that additional treatment needs to be rendered to restore other teeth that interfere with the restorative space, occlusal scheme, or esthetics. This is the most important function of a diagnostic wax-up — it provides diagnostic information that affects the treatment plan.[2,10]

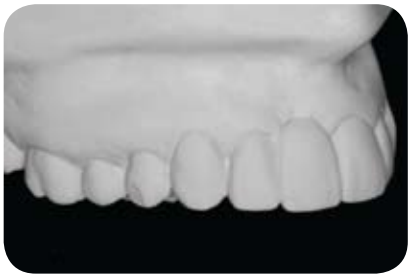

FIGURE 1A. Diagnostic casts demonstrating deficient gingival architecture.

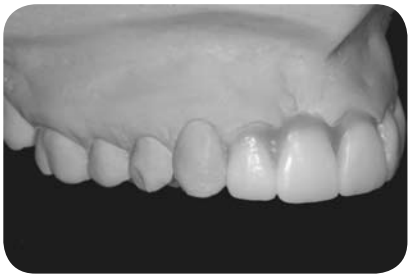

FIGURE 1B. Diagnostic wax-up of teeth and soft tissue demonstrating adequate tooth proportions and illustrating the need for gingival augmentation or gingiva-colored ceramics.

The diagnostic wax-up generally is being performed by a dental technician who is trained, experienced, and skilled in manipulating wax to form anatomically shaped teeth. However, without seeing the patient and without exact instructions regarding tooth length, width, position and inclination, the diagnostic wax-up becomes guesswork.[17]

When clinical guidance is unavailable, technicians use landmarks on the diagnostic casts to guide the waxing. Such landmarks may be the existing occlusal plane and the length and position of the remaining teeth. While this may work in some instances, it may introduce considerable error in other situations. If the remaining teeth are not in proper positions in relation to the patient's lips or other facial structures, they could act as an incorrect guide. This type of a wax-up may be misleading and of little clinical value. Although it illustrates anatomically correct teeth that appear acceptable on the cast, the teeth may not match the patient and may not represent the desired result that the clinician and the patient expected. If teeth are to be prepared for fixed restorations or implants are to be placed according to this wax-up, the result may be unpredictable.

For previously stated reasons, the dental technician should be involved directly with the patient at the diagnostic phase. A direct dialogue between the patient and the technician, without the clinician as mediator, has been suggested to ensure success.[10] Unfortunately, this approach may not be practical for every clinician or technician and therefore is not widely utilized. It is, therefore, extremely important to obtain as much clinical information as possible prior to the wax-up in order to create a clinically based diagnostic wax-up.

The information should be communicated with the technician to guide the waxing. The following factors would be important to relay to the technician: incisal edge position, midline, teeth length, width, and CEJ position. The potential need for soft tissue augmentation is considered and requested as a gingival tissue wax-up to evaluate the need for gingiva-colored ceramics[18] (**FIGURES 1A-B**). The desired incisal guidance is documented and

FIGURE 2A. Patient presented with a desire to improve her smile: Rest position.

FIGURE 2B. Smile demonstrating inadequate incisal display.

FIGURE 2C. Consequence of excessive tooth wear.

FIGURE 2D. Composite mock up done on the maxillary right central incisor to determine incisal edge position.

FIGURE 2E. Mock-up evaluated at rest position.

FIGURE 2F. Mock-up at smile.

the correct occlusal scheme is prescribed.

This article will discuss methods to predictably communicate desired teeth contours and positions to be waxed according to information obtained clinically. This will allow the formation of an accurate and clinically valid diagnostic wax-up for a predictable esthetic result.

Obtaining Clinical Information

FREEHAND METHOD

Using this technique, the desired positions of the teeth are communicated in relation to the existing dentition. The technician is instructed to wax the teeth while modifying the length, width, or midline of the existing teeth by a given amount in relation to the existing condition. This method can be practical when only limited alterations to the existing dentition are needed.

DIAGNOSTIC MOCK-UP

A diagnostic mock-up is the clinical equivalent of a laboratory made diagnostic wax-up.[19] In this approach, the teeth are being modeled intraorally using a tooth-colored material in a reversible way to demonstrate the desired esthetic result. Although a direct intraoral waxing technique using wax over the natural teeth has been documented, the use of tooth-colored resin materials seems to be more practical.[20] It is important to select a proper tooth-colored material to avoid any bias, since perception of shape may be influenced by opacity and color. This procedure can be done before or after the diagnostic wax-up.

Types of Diagnostic Mock-ups

PRELIMINARY DIAGNOSTIC MOCK-UP

A preliminary diagnostic mock-up is a powerful tool to obtain clinical information in a simplified way prior to the diagnostic wax-up.[5,15,16] In this technique, composite resin is used freehand intraorally to contour one or more teeth and evaluate the affect on the patient's appearance. This allows the clinician to visualize the change and see if the tentative teeth contour and position integrate with the face and lips (**FIGURES 2A-F**). Different lip positions can be evaluated to confirm an acceptable smile and rest position. Phonetic tests can be performed to evaluate the tentative incisal edge position vertically and buccolingually in relation to the vermilion border of the lower lip in F,V sounds.[21] At the same time, potential alteration in phonetics can be observed and discussed with the patient as adaptation to the new position will be required.[15,16]

In many cases, the patient may not be able to perceive the clinician's diagnosis and treatment plan without a visual aid. In those cases, the mock-up would be a critical step in educating the patient without which, treatment would not be performed.

The mock-up procedure is completely reversible and is done without any tooth preparation, without acid etching or bonding to the teeth. The composite is simply placed on the teeth in a freehand technique and contoured to become a guide for the wax-up. If there is any existing composite resin on the teeth, it

should be lightly lubricated to prevent adhesion to the mock-up. The mock-up can be evaluated prior to polymerization and contoured while still malleable, according to feedback obtained clinically. When the desired position has been obtained it is allowed to polymerize.

The procedure may begin by first contouring the central incisor to establish incisal edge position and midline, and obtain patient acceptance. Intentional excessive lengthening or shortening of the mock-up can be done to allow a discerning patient to visualize the difference and feel confident with his or her decision. If esthetic evaluation suggests lengthening of the tooth gingivally, a mock-up of the gingival margin of the tooth can be done to illustrate crown lengthening. This can be done by temporarily extending the composite resin from the teeth onto the tissue to form a new gingival margin (**FIGURES 3A-B**). On the other hand, if deficient gingival architecture is presented, gingiva-colored composite resin can be used over the teeth to illustrate gingival augmentation procedures or the future need of gingiva-colored ceramics (**FIGURES 4A-B**).[18] Shortening of the incisal edge position can be illustrated, if necessary, using a black marker to create an illusion of a shorter tooth.[5]

Following this, additional teeth may be included in the mock-up to demonstrate to the patient the proposed changes. Photographs documenting the new incisal edge position at rest and smile in relation to the lips may be taken. Additional photographs capturing the patient's face and profile could assist in matching teeth contours to facial features. These photographs capture essential clinical details and communicate important information that sometimes cannot be verbalized. Impressions with the composite mock-up in place can be made and poured in stone. Upon completion, the composite mock-up can be easily flaked off the teeth and saved for future reference (**FIGURE 5A**). The information is gathered and sent to the laboratory. The cast of the arch with the composite mock-up will be used by the technician as a clinically based guide for the diagnostic wax-up (**FIGURE 5B**).

The technician will create a diagnostic wax-up that follows the teeth that were built in the mock-up and will extend it to the remaining dentition

FIGURE 3A. Severe incisal wear combined with supra-eruption that altered the gingival margin position.

FIGURE 3B. Direct composite resin mock-up of the incisal edge position and gingival margin location allowed the patient to visualize the tentative plan.

FIGURE 4A. Deficient gingival architecture is evident in a provisional restoration of patient presented in Figure 1a.

FIGURE 4B. Direct mock-up is made on the provisional with gingiva-colored composite resin and is evaluated at smile to approve a diagnostic wax-up of teeth and gingival tissue presented in Figure 1b. This mock-up enables the clinician and the patient to visualize the use of gingiva-colored ceramics in the definitive prosthesis or discuss the option of soft tissue augmentation.

FIGURE 5A. Composite mock-up (from Figure 2) removed intact from the tooth.

FIGURE 5B. Mock-up placed on the diagnostic cast.

FIGURE 5C. Wax-up is made based on information obtained from diagnostic mock-up.

to be waxed (**FIGURE 5C**). This will be a refined version of the mock-up featuring proper contours, anatomy, and surface texture. Such diagnostic wax-up that is clinically based can be accurately used to diagnose additional conditions and guide the treatment predictably.

SECONDARY DIAGNOSTIC MOCK-UP

An additional diagnostic mock-up procedure has been documented in the literature.[2,13,15,16,22,23] This mock-up, which is sometimes being referred to as overlay prosthesis, is done after the diagnostic wax-up has been made. It is formed using a silicone matrix made from the diagnostic wax-up (**FIGURE 6A**). The matrix is filled with autopolymerizing resin (**FIGURE 6B**), placed over the unaltered natural teeth and removed upon final polymerization. The resin mock-up typically remains on the teeth as it is mechanically retained in undercuts (**FIGURE 6C-E**).

This procedure reproduces the wax-up onto the natural teeth for immediate clinical evaluation. It tests the final design details of the diagnostic wax-up clinically prior to any teeth preparation. It is an extremely valuable tool to fine-tune the desired configuration and contour of the planned restorations.

If necessary, it can be modified once again with direct composite and communicated with the technician using photographs and casts of the desired results. The procedure can be repeated until the desired result is acceptable to the patient and the restorative team (**FIGURES 6F-N, 7A-J**).

While a mock-up is typically made intraorally over the intact dentition, it can alternatively be made indirectly by the laboratory on an unaltered cast to be evaluated later intraorally by the clinician.[2,3,17,22,23]

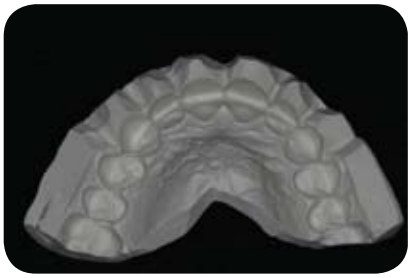

FIGURE 6A. A silicone matrix made from the diagnostic wax-up in Figure 5c is trimmed to facilitate creation of a secondary mock-up.

FIGURE 6B. The matrix is filled with autopolymerizing resin and placed over the teeth.

FIGURE 6C. Secondary mock-up in place evaluating the diagnostic wax-up design at rest position.

FIGURE 6D. Secondary mock-up at smile. Changes may be made according to clinical feedback.

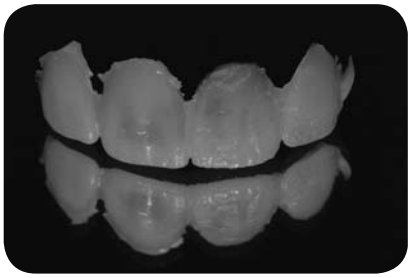

FIGURE 6E. The mock-up is removed upon completion.

FIGURE 6F. A corrected mock-up is made based on patient's feedback.

FIGURE 6G. The incisal edge position is evaluated in relation to the lip both esthetically and phonetically.

FIGURE 6H. Excess resin has to be removed from the gingival areas if the mock-up is to be used long term.

FIGURE 6I. Teeth preparation is done using depth cutting burs on the mock-up which acts as a full contour preparation guide and not on the original, worn tooth contour.

FIGURE 6J. Considerable reduction is done on the mock-up, which results in minimal tooth reduction and preservation of enamel while obtaining optimal preparation depth.

FIGURE 6K. The preparation is verified using a silicone matrix made from the final diagnostic wax-up. Symmetrical trimming of the matrix and consistent viewing angle are essential for accurate evaluation. Notice correct trimming of the matrix with proper viewing angle on the patient's left side compared to incorrect trimming and improper viewing angle on the contra lateral side.

FIGURE 6L. A provisional restoration made using the same silicone template is inserted.

FIGURE 6M. The definitive porcelain veneers follow the diagnostic wax-up made using information obtained clinically with the preliminary and secondary mock-ups.

FIGURE 6N. Patient's smile is adapting to the new incisal edge position.

REMOVABLE MOCK-UP PROVISIONAL RESTORATION

If the mock-up is designed to be removed intact, it can be used as a removable overlay prosthesis for the patient to wear over the teeth. This will allow the discerning patient to evaluate the design among friends and family members who may influence the patient's decision. This mock-up provisional is used until final approval of the teeth arrangement is obtained.[3]

FIXED MOCK-UP PROVISIONAL RESTORATION

Another approach is to use the mock-up as a preliminary fixed provisional restoration. The unaltered teeth are etched and a silicone matrix made from the diagnostic wax-up is used to bond the mock-up to the teeth.[13,15,16] This preliminary provisional restoration is designed to test the mock-up long term for esthetics and function. This will also allow preliminary evaluation of the design in a social environment outside the clinical setting.[16]

If the mock-up followed a purely additive wax-up (without any tooth reduction) and only spot etching was used to bond it, it can be easily flicked off and the teeth can be polished. This is not the case when the mock-up is based on a subtractive wax-up (tooth reduction needed for wax-up) or when the entire surface of the teeth was etched. It is important to note that in this approach the patient needs to be committed to treatment and proper consent is essential.

Discussion

It is well accepted today that the concepts of modern esthetic dentistry are founded in complete denture prosthodontics. Designing an esthetic smile in both edentulous and dentate patients requires the establishment of teeth positions for proper esthetics and function. According to prosthodontic principles, by establishing the incisal edge position and midline and following anatomical landmarks such as the retromolar pads to communicate the desired occlusal plane, the entire dentition can be designed on mounted casts in proper esthetic arrangement.[24,25]

If these principles are to be applied to fixed prosthodontics, an intraoral preliminary diagnostic mock-up of a single central incisor will be adequate to communicate with the technician the incisal edge position and midline and will function like the complete denture wax-rim. Using this information, the technician will be able to predictably wax the entire dentition.

The secondary mock-up will simulate the anterior teeth wax trial placement of complete dentures and once it is approved the work can be continued with a higher level of confidence.

In the event that tooth structure interferes with the diagnostic mock-

FIGURE 7A. Patient presented with inadequate configuration of incisal edges compared to the lip line and smile.

FIGURE 7B. Retracted view demonstrating improper tooth form.

FIGURE 7C. A silicone matrix made from the diagnostic wax-up is filled with autopolymerizing resin and placed on the teeth.

FIGURE 7D. A mock-up is formed upon polymerization of the resin.

FIGURE 7E. The mock-up tests the design of the wax-up in relation to the lip line and smile. Utilizing patient's feedback from the mock-up, an additional increase in incisal edge is prescribed.

FIGURE 7F. The wax-up was modified and another mock-up is tried in. The mock-up will program the lip line and prepare the soft tissues for the definitive restoration.

FIGURE 7G. Upon completion, the mock-up is removed.

up, minor tooth modifications may be needed. Care should be taken to obtain a complete patient consent as this is an irreversible diagnostic procedure.

These diagnostic techniques in conjunction with the mock-up provisional restoration concept are especially useful in a treatment plan that involves porcelain veneers. They are designed to address the precision needed in tooth preparation for these restorations and the difficulty in creating and maintaining long-term provisional restorations for porcelain veneers.

Since provisional veneers are typically retained using mechanical retention or spot bonding techniques, they have limited retention and durability. Given that they cannot be predictably maintained long term, it is unfeasible to evaluate the new design in function over the desired length of time. While some patients need time to accept the new appearance psychologically, in others the phonetics may need to be evaluated for a longer period. Over time, the new form may alter the patient's smile pattern and "de-program" the smile. This change may be unpredictable in magnitude and may require treatment modifications. The new occlusal scheme may need to be monitored in cases that modify the incisal guidance and the envelope of function. The techniques proposed in this article allow this to be done predictably until complete approval of the patient is obtained.

It is important to note that while a removable mock-up provisional is used according to the patient's discretion and may be in function for an unknown period or not at all, the fixed mock-up ensures patient compliance. It is more durable and may allow a longer trial period and therefore provide a reliable provisionalization.

Porcelain veneers are conservative restorations requiring minimal tooth preparation. However, without accurate guidance related to the definitive restoration contours, the teeth could be under-or overprepared resulting in a compromised result. In order to allow optimal tooth preparation the approved mock-up is used as a preparation guide. The teeth are prepared through the resin mock-up that represents the definitive tooth contours and allows a predictable and uniform reduction.

The various techniques described hereby can be used as stand-alone procedures to obtain a clinically valid diagnostic wax-up. However, when needed, they can be used in conjunction with each other to allow a more predictable result in difficult and demanding cases.

Conclusion

The diagnostic mock-up procedure is a reasonably quick and straightforward pro-

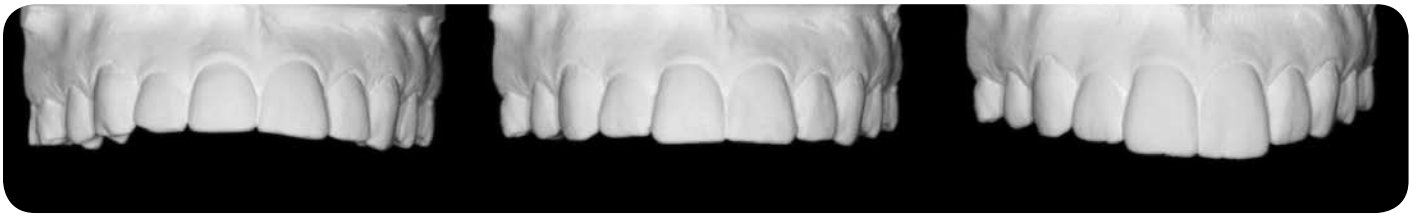

FIGURE 7H. Progression of diagnostic casts, from preoperative casts to initial wax-up and final wax-up demonstrating a total increase in incisal edge of 3 mm.

FIGURE 7I. Bonded porcelain restorations reproduce the diagnostic wax-up.

FIGURE 7J. Incisal edges are in harmony with the lower lip ensuring a predictable esthetic result. *(Figures 7a-j are reprinted with permission from Magne P, Belser U, Bonded porcelain restorations in the anterior dentition a biomimetic approach, first ed. Carol Stream, Ill., Quintessence Publishing Co., pages 221-3, 2002.)*

cedure that provides instant clinical feedback prior to the beginning of treatment.

The advantages of this technique are that the desired changes can be visualized clinically, tested with the patient's rest position and smile, as well as evaluated phonetically. In addition, the patient is actively involved in the diagnostic process providing feedback and sharing the responsibility for the final result. The patient will be more likely to accept a result that he or she visualized and co-diagnosed.

Obtaining clinical information to guide the diagnostic wax-up is an important concept. This method will enhance the predictability of the treatment, minimize loss of chairtime, and help to obtain patient acceptance from the beginning of treatment. ■■■■

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Smile Design for the Adolescent Patient — Interdisciplinary Management of Anterior Tooth Size Discrepancies

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ABSTRACT Adolescent patients often seek orthodontic treatment to correct spacing of the maxillary anterior teeth. If the spacing is caused by a tooth size discrepancy that affects one or more anterior teeth, an interdisciplinary treatment plan involving orthodontic, restorative, and periodontal treatment is recommended to achieve a harmonious esthetic result. This article describes a clinical approach for treatment of these complex cases, focusing on the importance of tooth form, gingival esthetics, and treatment sequencing.

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Despite the increase in adult orthodontic treatment demand over the last few years, children and adolescents still comprise the majority of the orthodontic patient population. Within this younger population, there has been a shift from traditional treatment goals, such as ideal occlusion and cephalometric standards, to include goals embodying principles of micro-esthetics and soft tissue harmony.[1,2] This has caused the orthodontic profession to place a greater emphasis on gingival esthetics, tooth form, and on interdisciplinary care in general. One area in which all of these principles can be directly applied is the interdisciplinary treatment of anterior tooth size discrepancies (TSD).

A TSD in the adolescent patient involving a diminution of maxillary anterior tooth size or altered tooth morphology may cause multiple anterior esthetic concerns such as interdental diastemata, gingival margin discrepancies, and poor clinical crown proportions. Treatment is complicated by the fact that the dentogingival complex is subject to significant growth-related changes during the treatment period. In this patient population, an esthetic and stable result is best achieved by combined interdisciplinary care of the orthodontist, periodontist, restorative dentist, and pediatric dentist.

The contemporary interdisciplinary team is skilled at correcting a single tooth discrepancy, such as a small lateral incisor.[3,4] However, when additional anterior teeth are involved, or when other significant hard and soft tissues discrepancies are present, a more thorough interdisciplinary approach is necessary to achieve excellent results. Clinical observation has led to identification of eight important factors when considering interdisciplinary treatment of significant anterior TSD.

Tooth Size

When the clinician is planning the correction of interdental spacing, a thorough tooth size analysis should be performed to determine the existence of a TSD. This should be done by measurements of individual teeth with a caliper that registers measurements within a 10th of a millimeter, and by performing a Bolton analysis, which compares the overall tooth mass in one arch relative to the other and can detect a TSD.[5] Othman and Harradine recommend a 2 mm discrepancy to be considered as a clinically significant threshold.[6]

If no TSD is detected, the space can often be closed successfully with orthodontic treatment alone (**FIGURE 1**). If, however, the tooth size analysis confirms that a TSD indeed exists, interdisciplinary treatment to enhance the size of the anterior teeth should be considered. Often, the first step in treatment planning is a diagnostic wax-up, which serves as a blueprint for the subsequent interdisciplinary treatment (**FIGURE 2**), and may be performed by the members of the interdisciplinary team, or by a skilled lab technician.[4] This step is especially important when the patient is missing one or more teeth, either as a result of traumatic loss or congenital absence.

FIGURE 1A. A patient with generalized spacing, but no measurable tooth size discrepancy.

FIGURE 1B. No interdisciplinary treatment was necessary and spaces were closed with orthodontic treatment alone.

FIGURE 2A. An adolescent patient with a generalized TSD characterized by a peg lateral No. 7, tapered and narrow central incisors, and congenitally missing No. 10.

FIGURE 2B. A diagnostic wax-up allowed the interdisciplinary team to envision the final size and shape of teeth Nos. 7-9, and helped to determine the correct amount of space to be left for implant replacement of No. 10.

FIGURE 3. This 13-year-old female presented with a chief complaint of spacing. Note the peg lateral No. 7 and the tapered (shovel-shaped) central incisors. Interdisciplinary treatment with orthodontic space management and cosmetic composite resin bonding of Nos. 7, 8, and 9 resulted in satisfactory dental esthetics. Failure to address the morphology of the central incisors would have caused esthetic failure of the case, due to a lack of proper mesial and distal contours, contact points, and embrasure spaces.

Tooth Form

The maxillary lateral incisor is commonly affected by the TSD and may present with a deficient mesio-distal width and inciso-gingival height. A specific phenotypic variant of the small lateral incisor is the "peg" lateral incisor (**FIGURE 3**), in which there is a characteristic conical shape of the clinical crown that tapers from the cervix of the tooth towards the incisal edge.[14] The maxillary central incisor may also be involved in the TSD, and often displays a flat and tapered mesial or distal contour (**FIGURE 3**). TSD of the central incisor is often overlooked, but is important to address as part of the overall treatment plan due to the prominent position of the central incisor in the dental arch.[7] When the canine is involved in the TSD, a "hooked" appearance of the canine may be unesthetic and create the perception of interdental spacing. This type of canine may benefit from inclusion in the restorative treatment phase.

Tooth Proportions

Achieving ideal tooth shape and proportion is an important goal of esthetic and interdisciplinary dentistry

FIGURE 4A. This 14-year-old male presented with generalized spacing caused by an anterior TSD affecting the morphology of all four maxillary incisors. In addition, No. 11 was impacted, and there was a mandibular asymmetry causing the mandibular dental midline to deviate to the left.

FIGURE 4B. Poor smile esthetics.

FIGURE 4C. Bracket on No. 10 was placed more incisally than usual to maintain the gingival margin height and avoid extrusion of the dento-gingival complex. Vertical space was created for lengthening No. 10 restoratively.

FIGURE 4D. All four incisors were bonded. Note the increased length of No. 10. After the bonding, it appeared that the central incisors were distally inclined due to the addition of composite on the distal aspect, so the central incisors were rebracketed to tip the crowns slightly mesially.

FIGURE 4E. Six-month post-treatment. No. 11 has gingival recession due to its initial ectopic eruption and will need a gingival graft.

FIGURE 4F. Post-treatment smile. Note the improvement in facial esthetics due to restoration of proper tooth form and arch width.

FIGURE 4G. Pretreatment dental cast: Anterior view.

FIGURE 4H. Pre-treatment dental cast: Maxillary occlusal view.

FIGURE 4I. Post-treatment dental cast: Anterior view.

FIGURE 4J. Post-treatment dental cast: Maxillary occlusal view.

and is increasingly becoming a routine part of orthodontic treatment goals.[8] The width-to-length ratios of the maxillary central and lateral incisors are 78-85 percent and 73-76 percent respectively.[9,10] The tooth-to-tooth width ratio of the maxillary lateral and central incisors has been recommended to be between 50-74 percent based on visual assessment by lay people and dentists, but is closer to 78 percent if based on available data of tooth widths.[11] Significant deviations from ideal clinical crown proportions may be caused by a TSD, incisal attrition, altered passive eruption, or gingival inflammation.

When a TSD only affects the lateral incisors, the central incisors may be used as a guide to establish the appropriate width of the lateral incisors based on ideal inter-tooth proportions. However, when the central incisors are also involved in the TSD, the interdisciplinary team must carefully plan for the restoration of both the central

and lateral incisors. This requires the practitioner to determine the ideal width of all four incisors and should be accomplished by means of a diagnostic wax-up, provisionalization, or by careful measurement and observation.

Occlusion

If a patient has a significant overjet, such as in a moderate or severe class II malocclusion, a reasonable treatment plan may involve closing the maxillary spacing with orthodontics alone, even in the presence of a documented TSD. This will allow reduction of the overjet by retraction of the anterior teeth. If, however, a patient does not exhibit excess overjet, such as in a class I or class III malocclusion, closing the space orthodontically without restorative dentistry may be detrimental for the functional occlusion due to possible over-retraction of the incisors. This may cause multiple long-term problems such as increased occlusal wear on the anterior teeth, crowding of the lower incisors, or relapse of the spacing. Furthermore, orthodontic space closure may lead to a constriction of the anterior arch width and may adversely affect smile esthetics.

Incisal Edge Position

Although a decreased mesial-distal width of an anterior tooth is often the most obvious element of a TSD, it is common for an anterior tooth, particularly the lateral incisor, to also be vertically deficient.[4] Addressing the vertical aspect of tooth form with an interdisciplinary approach will help establish the proper width-to-length ratio of the clinical crown, and will enable the restorative dentist to create an esthetically pleasing restoration.

To meet the demands of normal occlusion and acceptable esthetics, the incisal edge of the maxillary lateral incisor should be slightly apical to the incisal

FIGURE 5A. A 13-year-old female presented with a class I occlusion, with bilateral maxillary impacted canines and a TSD affecting the morphology of the maxillary central and lateral incisors.

FIGURE 5B. Intraoral view displaying interdental spacing, small tooth size, and a gingival margin height discrepancy between the central and lateral incisors.

FIGURE 5C. The lateral incisors were orthodontically intruded to correct the gingival margin discrepancy between the central and lateral incisors.

FIGURE 5D. After the gingival margins were leveled, direct composite restorations were performed on all four maxillary incisors and the brackets were replaced.

FIGURE 5E. The shape of the composite restorations was adjusted in the finishing stage of orthodontic treatment with an abrasive strip.

FIGURE 5F. One-year post-treatment photograph shows that a stable and esthetic result was achieved through the combined efforts of the interdisciplinary team.

FIGURE 5G. Excellent smile esthetics due to enhancement of tooth size and proper alignment of gingival margin.

FIGURE 5H. Pretreatment dental cast: Anterior view.

FIGURE 5I. Pretreatment dental cast: Maxillary occlusal view.

FIGURE 5J. Post-treatment dental case: Anterior view.

FIGURE 5K. Post-treatment dental case: Maxillary occlusal view. Note the harmonious anterior tooth size.

FIGURE 6A. A 13-year-old-male presented with small maxillary lateral incisors. Orthodontic treatment was initiated to center the lateral incisors in preparation for restorative treatment to enhance their mesial-distal width.

FIGURE 6B. Prior to the restorations, short clinical crowns were noted. Gingival inflammation (due to poor oral hygiene) and excessive pocket depth were the main etiologies of the short crown height.

FIGURE 6C. Excisional gingivectomies were performed prior to the composite bonding to increase the clinical crown length.

edge of the central incisor. However, if the incisal edge of the lateral incisor is in an excessively apical position relative to the adjacent central incisor, yet the gingival margin is in the correct vertical position, the lateral incisor should be maintained in this vertical position during orthodontic treatment and will be restored to its proper inciso-gingival length during the restorative phase (**FIGURE 4**). It is important for the orthodontist to consider this factor when determining the initial vertical position of the bracket. The lateral incisor bracket should be placed further incisally than usual, to avoid extruding the incisal edge and the gingival complex.

Gingival Margin Position

Gingival considerations must also be considered when assessing the vertical dimension of maxillary anterior teeth, particularly the lateral incisor. If the incisal edge of the lateral incisor is in a normal vertical position, but the gingival margin is coronal to its ideal position, the tooth may be intruded during orthodontic treatment to achieve a harmonious

FIGURE 6D. Direct composite veneers were placed on Nos. 7 and 10.

FIGURE 6E. Brackets were replaced for orthodontic finishing.

FIGURE 6F. Intraoral view on the day of orthodontic appliance removal.

FIGURE 6G. The finished result with regard to gingival and smile esthetics.

FIGURE 7A. Fourteen-year-old female undergoing phase II orthodontic treatment.

FIGURE 7B. Note the generalized spacing caused by a severe TSD. Due to the harm that orthodontic space closure and retraction of the incisors may have caused to the patient's facial esthetics, an interdisciplinary plan was initiated to ultimately restore all six maxillary anterior teeth.

FIGURE 7C. Following initial orthodontic space management, the space was limited to the maxillary anterior teeth.

FIGURE 7D. Maxillary occlusal view of orthodontic space preparation.

FIGURE 7E. Due to the short clinical crown heights of the lateral incisors, orthodontic intrusion was necessary to level the gingival margins and achieve a pleasing gingival esthetic outcome.

FIGURE 7F. Composite restorations were planned for all six anterior teeth. At this stage, the maxillary incisors have been bonded to an ideal width in order to determine the proportions of the lateral incisors and canines. The orthodontic brackets were replaced when the restorations were completed.

gingival margin relationship with the adjacent teeth[12] (**FIGURE 5**). The restorative phase will then involve vertical restoration of the incisal edge (in addition to the mesial-distal enhancement).[24]

If a coronally positioned gingival margin is due to inflammation (**FIGURE 6**) or altered passive eruption of the gingival tissue (**FIGURE 7**), an excisional gingivectomy may be performed prior to restoration to achieve the desired height of the restoration and contour of the gingival margin.[12] If the coronally positioned gingival margin is due to altered passive eruption of the osseous crest, periodontal treatment should be delayed until growth has ceased, at which time esthetic crown lengthening procedures with definitive osseous surgery should be performed to allow for establishment of the correct biologic width and to provide long-term stability of the corrected gingival margin.[13]

Restorative Material

Restoration of small maxillary incisors in the adolescent patient is often done with direct composite resin bonding.[3] Contemporary composites are esthetic, durable, and relatively affordable. Another advantage of composite resin is that it can be adjusted, if necessary, while the patient is still undergoing orthodontic treatment. The main disadvantage of composite resin is the potential for discoloration or degradation, and therefore the possible need for multiple replacements over the lifetime of the patient.

Another option for restorative materials is a lab-fabricated, indirect porcelain restoration, such as a veneer or a crown. While porcelain may offer excellent esthetics and may have a longer life span than composite, the main clinical disadvantage of a porcelain restoration for treating adolescent patients with a TSD is that it can only be placed after completion of orthodontics. Thus, the ability to use orthodontics to fine-tune spacing and crown form (**FIGURES 4 AND 5**) after the restorative treatment is lost.

It is also important to consider that the typical adolescent patient may undergo a number of years of vertical growth and general maturation of the gingival tissues after completion of orthodontic treatment. It may therefore be prudent to delay definitive porcelain restorations until vertical growth has ceased and stable gingival margins are achieved. At that point, the composite restorations can be removed and be replaced with veneers or crowns, depending on the amount of underlying tooth structure.

Treatment Timing and Sequencing

Treatment of adolescent patients displaying a significant TSD should be initiated when the patient has a full complement of permanent teeth, in order for the restorative dentist to have good access to the clinical crown during the restorative phase of interdisciplinary treatment. It is advantageous to perform composite restorations during active orthodontic treatment in order to enable ideal spacing prior to the restorative phase and to allow for any necessary modification of the spacing or restorations during the finishing stages of orthodontics. On the day of the restorations, the brackets should be

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FIGURE 7G. The second stage of the restorative treatment involved enhancement of the lateral incisors and canines. The short clinical crown height on the canines was due to altered passive eruption and was addressed with excisional gingivectomies to allow restorative access to the distal of the lateral incisors and the mesial of the canines.

FIGURE 7H. Two-week healing of the gingivectomies was excellent.

FIGURE 7I. Six-month post-treatment photographs.

FIGURE 7J. Interdisciplinary treatment of the anterior teeth created good tooth proportions.

FIGURE 7K. Three-quarter view. Excellent smile esthetics were achieved by restoring the anterior teeth to a normal size and by avoiding orthodontic retraction of the anterior teeth.

FIGURE 7L. Another view of smile esthetics. Porcelain veneers are planned on all six maxillary anterior teeth after final maturation of the gingival tissues to improve the shade match and to provide a long-term restorative solution. Since mild gingival asymmetry remains, further crown lengthening with removal of osseous tissue may be indicated at that time.

FIGURE 8A. A 13-year-old female presented for orthodontic treatment with generalized maxillary spacing, congenitally missing maxillary right lateral incisor (No. 7), and a small left lateral incisor (No. 10).

FIGURE 8B. Since the maxillary midline was deviated to the right, routine orthodontic mechanics to move the midline to the left could have caused space loss for restoration of No. 10.

FIGURE 8C. A decision was made to bond No. 10 early in treatment to prevent restorative space loss during midline correction, and to help the orthodontist develop a symmetric space for No. 7 implant restoration.

FIGURE 8D. At the conclusion of orthodontic treatment, an acceptable tooth size was accomplished for No. 10 and a symmetric amount of space was left for No. 7.

FIGURE 8E. Hawley retainer with pontic for No. 7.

FIGURE 8F. The final result shows correction of the midline, and proper space preparation for the eventual implant restoration of No. 7.

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removed by the orthodontist to allow for unfettered restorative access, and then should be replaced when the restorations are completed.[4] The restorative dentist should not attempt to fill all of the space, but should rather focus on achieving ideal crown form. If spacing remains, it will be closed by the orthodontist in the finishing stage of orthodontic treatment.

In cases with a congenitally missing lateral incisor and a contralateral small or peg lateral incisor, it is especially important to restore the small lateral incisor during the early stages of orthodontic treatment, prior to definitive space management. Early restoration of the appropriate width of the small lateral incisor serves as a guide for the space that should be left for replacement of the contralateral missing lateral incisor (**FIGURE 8**) and will avoid loss of restorative space for the small lateral incisor while configuring the space for the missing lateral incisor.

When a generalized TSD affects both the central and lateral incisors, restoration can be performed either simultaneously or in two stages. For the latter, the central incisors should generally be restored first (**FIGURE 7**) to set the proper proportions for the lateral incisors.

Discussion

The specific goals of treating adolescents with tooth size discrepancies are: the attainment of excellent static and functional occlusion, excellent gingival and smile esthetics, and harmonious tooth form. In most cases, these goals can best be met with an interdisciplinary approach.[14] By applying contemporary principles of smile design to each case, and following an appropriate sequence of treatment, clinical success can readily be achieved. In addition to orthodontic space management in the horizontal dimension, vertical tooth position and vertical gingival margin control are important in achieving an ideal restorative result.

Patients considering treatment for significant TSD should undergo a thorough informed consent process to understand the scope of work — orthodontic, periodontal, and restorative — that may be needed to achieve a satisfactory result. Patients must also be aware that ongoing maintenance of the restorations may be needed, and that they may best be served over the long term by converting composite restorations into porcelain restorations when gingival development is complete.

Conclusion

This article has outlined clinical principles for treating adolescent patients with a significant TSD. The comprehensive interdisciplinary approach should include the following distinct stages:

1) Interdisciplinary diagnosis and treatment plan.

2) Orthodontic space management. Leveling and alignment of the dentition, achievement of an ideal static and functional occlusion, and management of mesial-distal positioning of the maxillary anterior teeth in preparation for the restorative treatment.

3) Vertical management. Assessment of the incisal edge/gingival margin relationships for possible need of orthodontic intrusion, excisional gingivectomies, or definitive crown lengthening procedures.

4) Restorative phase. Ideal restoration of anterior teeth with direct composite resin bonding, based on principles of tooth form and proportionality.

5) Finishing. Orthodontic finishing details and modification of the composite restorations, as needed.

6) Retention/Long-term follow-up: Establishment of an effective orthodontic retention plan and a long-term follow-up protocol to monitor stability of the interdisciplinary result. In addition, the future option of definitive restorations with porcelain veneers or full-coverage crowns should be fully discussed. ■■■■

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Animal Revolt

One small step for mankind, but a real bummer for generations of frogs.

Robert E. Horseman, DDS

ILLUSTRATION BY CHARLIE O. HAYWARD

"Today," the instructor explained, "we will coat a rotating drum with some lampblack, attach some electrodes to a frog's leg and observe what happens when we apply 40,000 megavolts."

It was shortly after that I became a semi-supporter of animal rights groups. Physiology labs have been doing this sort of thing for ages, and all that ever happens is that the frog's leg predictably twitches when the current is applied. The fact that a record is made on the rotating drum in the name of science, does not justify the indignity in the slightest.

The only thing more traumatic from an apprehensive frog's point of view would be that the experiments take place in a French lab under the supervision of a cordon bleu chef.

You could look at that drum until your eyes bled and come to only one conclusion — duh. One small step for mankind, but a real bummer for generations of frogs who, if my worst fears are realized, will someday arise and wreak their vengeance on all of us who participated, albeit unwillingly, in these seemingly irrelevant experiments.

Even more horrendous were those hours in zoology labs where I was forced at gunpoint to dissect not only a frog, but an acanthus shark and, God forgive me, an actual cat. When you have an assortment of amphibian parts scattered over your desk, fingers slimed with what passes for frog blood and realize that from all this will come no major boost to your dental career, you know that you will never watch Kermit again with any peace of mind. No wonder he claims it's hard being green; man, it's downright fatal!

The possibility that animal experimentation may return someday to bite us

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Tippi Hedren emerged disheveled, but otherwise intact, to eventually become "den mother" to lions, tigers, leopards, and cougars at the Roar Foundation's Shambala Preserve near Acton, Calif.

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was illustrated a few years ago in a movie directed by a rotund English director named Alfred Hitchcock. His film, called "The Birds," was pitched for weeks prior to its premiere with the ungrammatical, but chillingly prophetic warning that "The Birds is coming!"

And they did, too. Millions of blackbirds, ravens, crows and gulls, setting aside for the moment whatever avian jealousies that had divided them, banded together to terrorize an entire town and one hapless inhabitant, Tippi Hedren, in particular.

It was not a pretty sight as the maddened creatures darkened the sky, speckling targets of opportunity below them and dominating the soundtrack with their demands that a government *of* the birds and *by* the birds would be *for* the birds and should be implemented immediately. I forget exactly how all this ended, except that the birds' agents were alarmed to observe their clients colliding at speeds exceeding 200 mph, making the likelihood of a sequel very iffy.

Tippi Hedren emerged disheveled, but otherwise intact, to eventually become "den mother" to lions, tigers, leopards, and cougars at the Roar Foundation's Shambala Preserve near Acton, Calif. She loves wild animals — birds, not so much — and will be most remembered for making it less onerous for women with comical names like Tuesday Weld, Whoopi Goldberg, and Tipper Gore to appear in public without embarrassment.

A jihad of birds is one thing, but an even more ominous possibility is the growing discontent evident in the canine population. For years, dental research involving dogs has been providing us with valuable information, none of which explains why they find it necessary to urinate so indiscriminately and how they can display so much unconditional affection to really bad persons.

From the dogs' point of view, no amount of stick throwing, scratching behind the ears, and succulent cans of Kennel Ration is going to make up for their discomfiture in the laboratory. Dogs are acutely aware of the unfairness of not being given opposable thumbs on their paws. Because of this anatomical oversight, even doorknobs that represent freedom to them become objects of unmanageable high-tech machinery, necessitating humiliating, and obsequious toadying.

It would not surprise me to learn that death squads of Rottweilers, Dobermans and pit bulls have been secretly formed to recruit Poodles, Yorkies and Beagles with the goal of plotting our comeuppance.

What's worse, one of our own, Lytle S. Adams, a dentist from Pennsylvania in the early days of World War II, had a brilliant idea to bring the Japanese conflict to an early conclusion. He's the one who came up with the notion of attaching small incendiary bombs to bats and dropping them out of airplanes to start the mother of all fires in Tokyo.

Considerable thought and $2 million of the taxpayers' money went into this scheme. After a couple of years of bat sitting and the formation of guano-intensive policing details, the War Department was ready for a test run at an air base near Carlsbad, New Mexico, with little dummy bombs.

The kamikaze bats, who discovered too late that their names were on the duty roster, were refrigerated to stop their whining, then the bombs were attached and the whole frigid flock flown in a B-26 to 5,000 feet for the test.

Alas, most of the bats, too groggy from their involuntary hibernation, augured straight in and died on impact. Back to the drawing board. Finally, in 1944, after a fire accidentally destroyed some of our own warehouse facilities by bats with a poorly developed sense of allegiance, the project was canceled.

The legends that are passed on by bats from one generation to the next, fix the blame for this whole fiasco squarely on the dentist who initiated the idea. That was 64 years ago during a Democratic administration. Bats today hate dentists and are solidly Republican.

Understandably, our relations with the animal kingdom are tenuous at best, and now that we're waging all-out war on the viruses and bacteria that hang out like homeless squatters in our offices, we will have managed to antagonize nearly every living species.

Watch your back. ■■■■